RESEARCH NEEDS FOR CONSERVING CALIFORNIA'S RARE PLANTS

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Abstract

California's is the largest state flora in the nation. Because of California's high level of plant endemism, rich agricultural heritage, and burgeoning human population, the state has more rare and endangered plants than any other. Lack of knowledge about some of these plants limits their conservation: taxonomic and distributional uncertainty often precludes active conservation, since dubious or poorly known taxa are a lower conservation priority and resources for conservation efforts are scarce. For two reasons this predicament is more extreme in California than elsewhere. First, on a strictly proportional basis, large floras are less well known. Second, much of the flora is young and evolving rapidly (or was before human interruption), resulting in limited morphological and genetic divergence and reproductive isolation among closely related plants. Many taxonomic treatments are consequently unstable: rare variants are relegated to taxonomic synonymy by one author only to be recognized by later authors, or vice versa (Edwards and Clinnick 1993). During preparation of the fifth edition of the California Native Plant Society (CNPS) *Inventory of Rare and Endangered Vascular Plants* of California (Skinner and Pavlik 1994), the editors identified over 150 instances of taxonomic and distributional uncertainty which might be clar-

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ified by carefully designed systematic and field studies. Further investigation has revealed many others. All are presented here, along with a compendium of California's extinct plants, some of which have potential to be rediscovered. California botanists can help alleviate botanical uncertainty by undertaking appropriate biosystematic or field studies that focus on problematic groups or taxa within California's rare flora. We suggest that the CNPS Rare Plant Program's Rare Plant Scientific Advisory Committee is the ideal agent to coordinate and track systematic and distributional studies of California's rare plants. The Rare Plant Program already maintains active databases tracking progress on the rare plant information needs in California, and CNPS is introducing a new grant program focusing on fundamental rare plant research in California. The involvement of other institutions is encouraged. In particular, faculty members at teaching institutions can contribute through appropriate guidance of graduate research. We urge California's botanical community to participate in these efforts and contribute to better understanding and enhanced protection of California's rare and endangered flora.

Research on rare and endangered plants takes many forms. Among the more stimulating are studies of rare plant population demographics (Pavlik and Barbour 1988), factors limiting rare plant establishment, persistence, reproduction, or reintroduction (Nickrent and Wiens 1989; Pavlik et al. 1993), population genetic diversity and its relationship to endemism, rarity, and conservation (Kress et al. 1994, Soltis et al. 1992), rare plant origins or relationships (Gottlieb 1973, 1974), effects of exotic plants and animals on endangered plants (Clark et al. 1990; Davis and Sherman 1992), and population viability analyses (Menges 1991). Much of this research is funded by state and federal agencies to support the conservation or recovery of legally protected species, and its legacy is a better understanding of the ecology and conservation needs of some of the hundreds of rare and endangered plants in California and the rest of the nation. Nevertheless, existing studies of a few endangered plants must not obscure the reality that most rare plants have not been studied at all, especially with respect to information fundamental to establishing priorities for their conservation (Parnell 1993). This information includes distribution and habitat preferences, degree of differentiation from close relatives and appropriate taxonomic rank, and the presence and extent of natural hybridization.

This is significant since lack of information or disagreement about the taxonomy or distribution of rare plants is frequently an impediment to their conservation (Messick 1987). Land managers and resource professionals are understandably reluctant to expend time and money conserving taxonomically questionable or poorly known taxa, because further research may show that these plants do not merit scientific recognition or are more common than previously thought. As the plant conservation crisis intensifies and conservation resources dwindle, conservationists increasingly must rely on accurate information to establish conservation priorities.

Lack of information is especially acute in California because of its large flora (over 6000 native taxa) and preponderance of rare

endemics (Stebbins and Major 1965), many of which are still in the process of diverging from common ancestors and are hence poorly separable from sister taxa. The presence of so many taxa which vary in geographically complex ways (e.g., *Astragalus lentiginosus* and its many endemic varieties) and typically hybridize at zones of contact or with closely related taxa (e.g., many rare *Lilium* species) means that in many cases circumscription of taxa and definition of their ranges is difficult and requires intensive effort rather than casual surveys.

The recent publication of two significant botanical reference works in California has highlighted much of what we do and do not know about California's rare flora, and stimulated preparation of this paper. *The Jepson Manual* (Hickman 1993; hereafter called the *Manual*) is the first comprehensive flora for California since *A California Flora and Supplement* (Munz and Keck 1973). The fifth edition of the California Native Plant Society (CNPS) *Inventory of Rare and Endangered Vascular Plants of California* (Skinner and Pavlik 1994; hereafter called the *Inventory*) contains information on the distribution, ecology, and conservation status for all the plants in California judged to be rare, threatened, or uncommon. The *Manual* summarizes much of what we know about the California flora as a whole, while the *Inventory* is widely considered the standard reference for California's plant conservation efforts. Each of these references, and the State of California's Natural Diversity Data Base (NDDB) of locations and status of rare and endangered taxa and natural communities, notes numerous instances of uncertainty about the taxonomic recognition, ecology, or distribution of certain of California's more than 1740 taxa of rare plants.

Coordination of Research

Our purpose here is to summarize this considerable uncertainty, and catalogue opportunities for fundamental research and study that can facilitate rare plant conservation in California. We have organized this summary of research needs for California's rare flora into three categories, each represented below by an information table. The first category is taxonomic uncertainty (Table 1); the second, distributional uncertainty (Table 3); and the last lists the extinct plants in California (Table 4), many of which require immediate field work to ascertain if they can be rediscovered given sufficient effort. Taxonomic circumscription and plant distribution are clearly not independent; since different taxonomic schemes and concepts dictate different distributions for the plants involved, those cases where both taxonomy and distribution are uncertain are listed in Table 1.

We urge interested botanists to use this compilation to focus their

TABLE 1. COMPILATION OF TAXONOMIC RESEARCH NEEDS FOR THE RARE FLORA OF CALIFORNIA. Criteria for inclusion are discussed in the text. "Uncertain distinctiveness" means that taxonomic limits are unknown and taxa in question may or may not merit formal recognition. "Uncertain circumscription" means that taxa are distinctive and probably do merit taxonomic recognition, but taxonomic limits are vague or unknown. Rare plants with significant taxonomic and distributional questions are included here rather than in Table 3. Consult Hickman (1993), Skinner and Pavlik (1994), and the CNPS Rare Plant Program for more information about each entry. JM Author(s) of *The Jepson Manual* treatment. * Research completed, but not yet published. † Deceased.

Scientific name	Authorities	Research problem
Achnatherum lemmonii var. *pubescens*	Mary E. Barkworth[JM]/Beecher Crampton	Uncertain distinctiveness from var. *lemmonii,* as all known var. *pubescens* co-occur with typical variety.
Agrostis hendersonii	M. J. Harvey[JM]/James D. Jokerst	Some populations show uncertain distinctiveness from *A. microphylla,* leading to uncertainty about range.
Alopecurus aequalis var. *sonomensis*	William J. Crins[JM] *	Uncertain distinctiveness from var. *aequalis.*
Arabis modesta	Reed C. Rollins[JM]/Linda Ann Vorobik*	Uncertain distinctiveness from *A. oregana.*
Arabis oregana	Reed C. Rollins[JM]/Linda Ann Vorobik*	Uncertain taxonomic status of occurrences from Napa Co.
Arabis serpentinicola	Reed C. Rollins[JM]/Linda Ann Vorobik*	Relationship to *A. macdonaldiana* needs formalization.
Arctostaphylos peninsularis ssp. *peninsularis*	Philip V. Wells[JM]/Jon E. Keeley	Uncertain relationship to Baja California plants of same name.
Arnica venosa	Theodore M. Barkley[JM]/James D. Jokerst/ Steven J. Wolf/William Gruezo	Some plants seem intermediate to *A. discoidea.*
Aster lentus	Geraldine A. Allen[JM]	Uncertain circumscription from *A. chilensis.*
Atriplex tularensis	Dean W. Taylor * & Dieter H. Wilken[JM]/Kathy E. Freas & Dennis D. Murphy/Hilda Flores/Howard Stutz & Ge-Lin Chu	Plant possibly extinct: only remaining occurrence may be an undescribed form of *A. serenana.*
Balsamorhiza sericea	David J. Keil[JM]/W. A. Weber	Uncertain distinctiveness from *B. macrolepis* var. *platylepis.*
Berberis fremontii	Michael P. Williams[JM]/Andrew C. Sanders/ Alan Whittemore	Uncertain distinctiveness of synonymized rare taxa (e.g., *B. higginsiae*).
Blennosperma nanum var. *robustum*	Robert Ornduff[JM]	Uncertain circumscription from var. *nanum.*

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Calamagrostis crassiglumis	Craig W. Greene[JM]	Uncertain distinctiveness from *C. stricta* ssp. *inexpansa* and *C. nutkaensis.*
Calycadenia villosa	Robert L. Carr & Gerald D. Carr[JM] */Bruce G. Baldwin & Susan J. Bainbridge	Probably consists of northern and southern unrecognized subspecies.
Calystegia atriplicifolia ssp. *buttensis*	Richard K. Brummitt[JM]	Uncertain distribution, abundance, and circumscription from ssp. *atriplicifolia.*
Calystegia malacophylla var. *berryi*	Richard K. Brummitt[JM]	Uncertain distinctiveness from ssp. *malacophylla.*
Camissonia lewisii	Warren L. Wagner[JM]/Peter H. Raven	Uncertain distribution, abundance, and circumscription of species in *C. lewisii* complex.
Castilleja gleasonii	T. I. Chuang† & Lawrence R. Heckard†[JM]/ Orlando Mistretta/Margriet Wetherwax	*C. pruinosa* complex is highly variable and confusing.
Castilleja montigena	T. I. Chuang† & Lawrence R. Heckard†[JM]/ Margriet Wetherwax	Is taxon true breeding and valid, or merely a sporadic F1 hybrid?
Castilleja uliginosa	T. I. Chuang† & Lawrence R. Heckard†[JM]/ Margriet Wetherwax	Uncertain distinctiveness from *C. miniata* ssp. *miniata,* but plant presumed extinct.
Ceanothus confusus	Clifford L. Schmidt[JM]	Possibly a variety of *C. prostratus.*
Ceanothus divergens	Clifford L. Schmidt[JM]	Possibly a variety of *C. purpureus.*
Ceanothus masonii	Clifford L. Schmidt[JM]/V. Thomas Parker	Possibly a variety of *C. gloriosus.*
Ceanothus xotayensis	Clifford L. Schmidt[JM]/Andrew C. Sanders	Is taxon true breeding and valid?
Ceanothus sonomensis	Clifford L. Schmidt[JM]	Possibly a variety of *C. cuneatus.*
Chorizanthe cuspidata vars. *cuspidata* and *villosa*	James C. Hickman†[JM]/James L. Reveal & Clare Hardham	Uncertain circumscription of varieties; entire *Pungentes* complex needs study.
Chorizanthe pungens vars. *hartwegiana* and *pungens*	James C. Hickman†[JM]/James L. Reveal & Clare Hardham/R. Morgan/Barbara J. Ertter	Uncertain circumscription of varieties; entire *Pungentes* complex needs study.
Chorizanthe robusta vars. *hartwegii* and *robusta*	James C. Hickman†[JM]/James L. Reveal & Clare Hardham/R. Morgan/Barbara J. Ertter	Uncertain circumscription of varieties; entire *Pungentes* complex needs study.

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Cirsium occidentale var. *compactum*	David J. Keil & Charles E. Turner[JM]/Vernal L. Yadon	Uncertain circumscription of varieties; are differences environmentally induced?
Clarkia mosquinii sspp. *mosquinii* and *xerophila*	Harlan Lewis[JM]/Lawrence Janeway/Les Gottlieb	Uncertain distribution, abundance, and distinctiveness of subspecies (are leaf differences environmentally induced?).
Claytonia lanceolata var. *peirsonii*	Kenton L. Chambers[JM]/John Miller/Orlando Mistretta	Uncertain distinctiveness from other varieties.
Cordylanthus tenuis ssp. *pallescens*	T. I. Chuang† & Lawrence R. Heckard† [JM]/Don Burk/Margriet Wetherwax	Uncertain distinctiveness from ssp. *viscidus.*
Corethrogyne filaginifolia vars. *incana* and *linifolia*	Meredith A. Lane[JM]	Uncertain circumscription from *Lessingia filaginifolia* var. *filaginifolia,* into which these rare varieties with unclear morphological basis and distribution have been merged.
Corethrogyne leucophylla	Meredith A. Lane[JM]	Uncertain circumscription from *Lessingia filaginifolia* var. *filaginifolia,* into which this taxon has been merged.
Cryptantha clevelandii var. *dissita*	Walter A. Kelly & Dieter H. Wilken[JM]	Uncertain distinctiveness from var. *clevelandii.*
Cryptantha rattanii	Walter A. Kelly & Dieter H. Wilken[JM]	Uncertain distinctiveness from *C. decipiens.*
Cryptantha scoparia	Walter A. Kelly & Dieter H. Wilken[JM]	Uncertain distinctiveness from *C. nevadensis.*
Cupressus stephensonii	Jim A. Bartel[JM]/Connie Millar	Uncertain distinctiveness from *C. arizonica* ssp. *arizonica.*
Delphinium luteum	Michael J. Warnock[JM]	Uncertain extent of introgression with close relatives.
Delphinium variegatum sspp. *kinkiense* and *thornei*	Michael J. Warnock[JM]	Uncertain distinctiveness of subspecies.
Dendromecon harfordii vars. *harfordii* and *rhamnoides*	Curtis Clark[JM]	Highly variable; uncertain distinctiveness of varieties.
Dicentra formosa ssp. *oregana*	Curtis Clark[JM]/Kingsley Stern	Uncertain distinctiveness from ssp. *formosa.*
Dichanthelium lanuginosum var. *thermale*	Robert Webster[JM]/Sally deBecker	Uncertain circumscription from *Panicum acuminatum* var. *acuminatum.*

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Dudleya alainae	Jim A. Bartel[JM]/Craig Reiser/James C. Dice/Kei Nakai/Reid Moran	Uncertain distinctiveness from *D. saxosa* ssp. *aloides.*
Echinocereus engelmannii var. *howei*	Edward F. Anderson[JM]/Maile Neel/Lyman Benson†	Uncertain distinctiveness of this and other varieties.
Empetrum nigrum ssp. *hermaphroditum*	Fosiée Tahbaz[JM]	Uncertain validity of subspecies; if valid, are any CA plants this variety?
Eremalche kernensis	David M. Bates[JM]/Dean W. Taylor & W. B. Davilla/Susan Mazer	Uncertain circumscription of taxa in the *E. parryi/E. kernensis* complex.
Erigeron calvus	Guy L. Nesom[JM]	Unknown distribution, abundance, and distinctiveness from *E. divergens* and *E. aphanactis* var. *aphanactis.*
Eriogonum beatleyae	James C. Hickman†[JM]/James L. Reveal	Uncertain distinctiveness from *E. ochrocephalum* and *E. rosense.*
Eriogonum eastwoodianum	James C. Hickman†[JM]/James L. Reveal	Uncertain distinctiveness from *E. temblorense* and *E. vestitum.*
Eriogonum luteolum var. *caninum*	James C. Hickman†[JM]/James L. Reveal	Uncertain circumscription from var. *luteolum;* distribution needs clarification.
Eriogonum temblorense	James C. Hickman†[JM]/James L. Reveal	Uncertain distinctiveness from *E. eastwoodianum* and *E. vestitum.*
Eriogonum vestitum	James C. Hickman†[JM]/James L. Reveal	Uncertain distinctiveness from *E. eastwoodianum* and *E. temblorense.*
Eryngium spinosepalum	Lincoln Constance[JM]	Uncertain degree of introgression with *E. castrense* and *E. vaseyi.*
Erythronium howellii	Geraldine A. Allen[JM]/James R. Shevock	Uncertain distinctiveness from *E. citrinum.*
Eschscholzia minutiflora ssp. *twisselmannii*	Curtis Clark[JM]/Mark Faull	Uncertain distinctiveness of subspecies.
Eschscholzia procera	Curtis Clark[JM]	Uncertain distinctiveness from *E. californica.*
Fritillaria roderickii	Bryan D. Ness[JM]/Walter Knight	Uncertain distinctiveness from *F. biflora* var. *biflora.*
Gentiana affinis var. *parvidentata*	James S. Pringle[JM]	Unknown distribution (is plant in CA?), abundance, and distinctiveness from var. *ovata.*
Helianthemum suffrutescens	Elizabeth McClintock[JM]/John Willoughby and James R. Shevock	Uncertain distinctiveness from *H. scoparium.*

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Helianthus exilis	David J. Keil[JM]/S. K. Jain & A. M. Olivieri	Uncertain distinctiveness from *H. bolanderi.*
Hemizonia congesta ssp. *leucocephala*	David J. Keil[JM]/Barry Tanowitz/Bruce G. Baldwin	Uncertain distinctiveness from ssp. *congesta*; herbarium specimens may be indistinguishable.
Heuchera duranii	Patrick E. Elvander[JM]	Uncertain distinctiveness from *H. parvifolia.*
Horkelia cuneata sspp. *sericea* and *puberula*	Barbara J. Ertter[JM]	Complex clinal variation of subspecies.
Horkelia marinensis	Barbara J. Ertter[JM]	Are Mendocino Co. populations near Ft. Bragg varietally distinct?
Ivesia argyrocoma	Barbara J. Ertter[JM]	Are Baja California populations varietally distinct?
Lathyrus sulphureus var. *argillaceus*	Duane Isely[JM]/Steven Broich	Uncertain distinctiveness from var. *sulphureus*; distribution and abundance poorly known.
Lavatera assurgentiflora sspp. *assurgentiflora* and glabra	Steven R. Hill[JM]/R. N. Philbrick/Marty Ray	Uncertain distinctiveness of subspecies.
Lessingia arachnoidea	Meredith A. Lane[JM]	Uncertain species circumscription; relationship to *L. holooleuca* unclear.
Lewisia cotyledon vars. *heckneri* and *howellii*	Lauramay T. Dempster[JM]	Uncertain distinctiveness of rare varieties.
Lewisia oppositifolia	Lauramay T. Dempster[JM]	CA plants possibly hybrids with *C. nevadensis.*
Lewisia serrata	Lauramay T. Dempster[JM]/Lawrence R. Heckard† & G. L. Stebbins	Uncertain distinctiveness from *L. cantelovii.*
Limnanthes floccosa ssp. *bellingeriana*	Robert Ornduff[PM]/Mary T. Kalin Arroyo/ Darlene Southworth	Uncertain distinctiveness in CA from ssp. *floccosa.*
Lomatium foeniculaceum ssp. *inyoense*	Lincoln Constance[JM]	Possibly a form induced by high-altitude conditions.
Lupinus albifrons var. *abramsii*	Teresa Sholars[JM]/Vernal L. Yadon	Uncertain distribution and distinctiveness from var. *albifrons*; only specimens from the Partington Ridge area, Monterey Co. match the type.
Lupinus croceus var. *pilosellus*	Teresa Sholars[JM]	Uncertain distinctiveness from var. *croceus.*
Lupinus elatus	Teresa Sholars[JM]	Unclear basis of distinction from *L. adsurgens* and *L. andersonii.*

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Lupinus eximius	Teresa Sholars[JM]	Uncertain distinctiveness from *L. arboreus*; taxonomic confirmation needed for Sonoma Co. plants.
Lupinus magnificus vars. *glarecola* and *hesperius*	Teresa Sholars[JM]	Uncertain distinctiveness of rare varieties.
Lupinus milo-bakeri	Rhonda Riggins[JM]/Teresa Sholars/Walter Knight	Uncertain distinctiveness from *L. luteolus.*
Lycium brevipes var. *hassei*	Michael Nee[JM]/Andrew C. Sanders	Uncertain distinctiveness from var. *brevipes.*
Lycium verrucosum	Michael Nee[JM]	Possibly a form of *L. brevipes.*
Malacothamnus arcuatus	David M. Bates[JM]	Uncertain distinctiveness from *M. fasciculatus.*
Malacothamnus davidsonii	David M. Bates[JM]	Unclear distribution and basis of distinction from *M. fasciculatus.*
Malacothamnus fasciculatus var. *nesioticus*	David M. Bates[JM]/Susan M. Swensen et al.*	Uncertain distinctiveness from other varieties.
Malacothamnus gracilis	David M. Bates[JM]	Uncertain distinctiveness from *M. jonesii.*
Malacothamnus hallii	David M. Bates[JM]	Uncertain distinctiveness from *M. fasciculatus.*
Malacothamnus helleri	David M. Bates[JM]	Uncertain distinctiveness from *M. fremontii.*
Malacothamnus mendocinensis	David M. Bates[JM]	Uncertain distinctiveness from *M. fasciculatus.*
Malacothamnus niveus	David M. Bates[JM]	Uncertain distinctiveness from *M. jonesii.*
Malacothamnus palmeri vars. *involucratus, lucianus,* and *palmeri*	David M. Bates[JM]/Vernal L. Yadon	Uncertain distinctiveness of varieties.
Malacothamnus parishii	David M. Bates[JM]	Uncertain distinctiveness from *M. fasciculatus.*
Mimulus acutidens	David M. Thompson[JM]	Uncertain distribution, abundance, and distinctiveness from *M. inconspicuus.*
Mimulus aridus	David M. Thompson[JM]	Uncertain circumscription of this and related taxa.
Mimulus brachiatus	David M. Thompson[JM]	Uncertain distribution and distinctiveness from *M. layneae.*
Mimulus brandegei	David M. Thompson[JM]	Uncertain distinctiveness from *M. latifolius,* but presumed extinct.
Mimulus diffusus	David M. Thompson[JM]	Uncertain distinctiveness from *M. palmeri.*

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Mimulus flemingii	David M. Thompson[JM]	Uncertain circumscription of this and related taxa.
Mimulus glabratus ssp. *utahensis*	David M. Thompson[JM]	Uncertain distinctiveness from *M. guttatus.*
Mimulus grayi	David M. Thompson[JM]	Uncertain distinctiveness from *M. inconspicuus.*
Mimulus microphyllus	David M. Thompson[JM]	Uncertain distinctiveness from *M. guttatus.*
Mimulus rattani ssp. *decurtatus*	David M. Thompson[JM]	Uncertain distinctiveness from ssp. *rattanii.*
Mimulus subsecundus	David M. Thompson[JM]	Uncertain distinctiveness from *M. fremontii.*
Mimulus whipplei	David M. Thompson[JM]	Uncertain distinctiveness from *M. guttatus.*
Monardella antonina sspp. *antonina* and *benitensis*	James D. Jokerst[JM]/Clare Hardham	Uncertain circumscription and distribution of varieties, which are similar to *M. villosa* ssp. *villosa.*
Monardella linoides ssp. *oblonga*	James D. Jokerst[JM]	Uncertain distinctiveness from ssp. *linoides.*
Monardella robisonii	James D. Jokerst[JM]	Possibly a variety of *M. linoides*; taxonomic confusion contributes to uncertain distribution in California; may occur in Baja California.
Myosurus minimus ssp. *apus*	Dieter H. Wilken[JM]/Alan Whittemore	Uncertain distribution and distinctiveness from *M. sessilis*; possibly a poorly stabilized hybrid between *M. minimus* and *M. sessilis,* at least in the Central Valley.
Opuntia munzii	Bruce D. Parfitt & Marc A. Baker[JM]/Andrew C. Sanders	Origin uncertain but taxon is valid; possible hybrid of *O. bigelovii* and *O. echinocarpa.*
Opuntia parryi var. *serpentina*	Bruce D. Parfitt & Marc A. Baker[JM]/Lyman Benson†	Uncertain circumscription from var. *parryi.*
Opuntia wigginsii	Bruce D. Parfitt & Marc A. Baker[JM]	Uncertain distinctiveness from *O. ramosissima*; possibly a sporadic hybrid between *O. ramosissima* and *O. echinocarpa.*
Pedicularis dudleyi	Linda Ann Vorobik[JM]	Southern plants somewhat distinctive; variation in the species needs further study.
Penstemon cinereus	Noel H. Holmgren[JM]/Elizabeth Chase Neese	Uncertain distinctiveness from *P. humilis* var. *humilis.*
Perideridia leptocarpa	Lincoln Constance[JM]	Uncertain distinctiveness from *P. oregana.*
Petalonyx thurberi ssp. *gilmanii*	Barry A. Prigge[JM]	Uncertain distinctiveness from ssp. *thurberi.*
Phacelia amabilis	Dieter H. Wilken, Richard R. Halse & Robert W. Patterson[JM]/Lincoln Constance	Uncertain distinctiveness from *P. crenulata.*

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Phacelia ciliata var. *opaca*	Dieter H. Wilken, Richard R. Halse & Robert W. Patterson[JM]/Lincoln Constance	Uncertain distinctiveness from var. *ciliata.*
Plagiobothrys chorisianus var. *chorisianus*	Timothy C. Messick[JM]	Uncertain distinctiveness from var. *hickmanii*; differences may be environmentally induced.
Plagiobothrys diffusus	Timothy C. Messick[JM]/Roy E. Buck	Uncertain distribution and distinctiveness from *P. reticulatus* var. *rossianorum.*
Plagiobothrys glaber	Timothy C. Messick[JM]	Possibly a variety of *P. stipitatus.*
Plagiobothrys glyptocarpus var. *modestus*	Timothy C. Messick[JM]	Uncertain position in the *P. glyptocarpus/P. distantiflorus* complex; possibly a minor variant or hybrid.
Plagiobothrys myosotoides	Timothy C. Messick[JM]	Identification uncertain; unclear relationship to *P. torreyi* complex. More South American specimens needed for comparison with CA material.
Platystemon californicus var. *ciliatus*	Curtis Clark[JM]/R. N. Philbrick/Gary Hannan	Uncertain distinctiveness from var. *californicus.*
Pogogyne douglasii ssp. *parviflora*	James D. Jokerst[JM]	Uncertain distinctiveness of subspecies; Central Valley populations of ssp. *parviflora* possibly distinct from those of the Coast Ranges.
Polemonium chartaceum	Dieter H. Wilken[JM]/Daniel Pritchett*	Disjunct occurrences may be taxonomically distinct.
Polygonum marinense	James C. Hickman†[JM]	Uncertain distinctiveness; related to *P. aviculare,* possibly = *P. robertii* (in *The Jepson Manual*), not native in CA.
Polygonum polygaloides ssp. *esotericum*	James C. Hickman†[JM]/Glen Clifton	Uncertain circumscription of *P. polygaloides* subspecies.
Psilocarphus elatior	James D. Morefield[JM]	Uncertain distribution and abundance in northern CA; possibly a variant of *P. brevissimus* var. *brevissimus.*
Puccinellia californica	Jerrold I. Davis[JM]/Andrew C. Sanders	Uncertain distinctiveness from *Puccinellia* simplex.
Puccinellia parishii	Jerrold I. Davis[JM]	Uncertain circumscription from *Torreyochloa pallida* var. *pauciflora.*
Rhus trilobata var. *simplicifolia*	Dieter H. Wilken[JM]/Geoffrey A. Levin	Uncertain distribution and distinctiveness of varieties.
Ribes amarum var. *hoffmannii*	Michael R. Mesler & John O. Sawyer, Jr.[JM]	Uncertain distinctiveness from var. *amarum.*
Ribes menziesii var. *ixoderme*	Michael R. Mesler & John O. Sawyer, Jr.[JM]	Uncertain distinctiveness of varieties.

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Rubus glaucifolius var. *ganderi*	Barbara J. Ertter[JM]	Uncertain distinctiveness from var. *glaucifolius.*
Salvia dorrii var. *incana*	Deborah Engle Averett & Kurt R. Neiess[JM]/ Jeffrey L. Strachan	Uncertain distinctiveness of variety in CA.
Sanguisorba officinalis	Barbara J. Ertter[JM]/Calder & Roy Taylor	CA plants may be ssp. *microcephala.*
Scrophularia atrata	Margriet Wetherwax[JM]/David Magney	Uncertain degree of introgression with *S. californica* ssp. *floribunda.*
Sedum laxum sspp. *flavidum* and *heckneri*	Melinda F. Denton†[JM]	Uncertain distinctiveness of rare subspecies.
Senecio clevelandii vars. *clevelandii* and *heterophyllus*	Theodore M. Barkley[JM]	Uncertain distinctiveness of varieties.
Silene occidentalis ssp. *longistipitata*	Dieter H. Wilken[JM]/John K. Morton	Uncertain distribution and distinctiveness from ssp. *occidentalis.*
Solanum clokeyi	Michael Nee[JM]/Tim Ross/Steve Junak	Uncertain circumscription from *S. wallacei. S. xanti* complex needs revision.
Solanum wallacei	Michael Nee[JM]/Tim Ross/Steve Junak	Uncertain distribution and circumscription from *S. clokeyi* and *S. xanti*; mainland occurrences in Santa Barbara and San Luis Obispo counties are probably *S. xanti. S. xanti* complex needs revision.
Streptanthus albidus ssp. *peramoenus*	Roy E. Buck, Dean W. Taylor & Arthur R. Kruckeberg[JM]/Niall F. McCarten	Uncertain distribution and distinctiveness from *S. glandulosus.*
Streptanthus batrachopus	Roy E. Buck, Dean W. Taylor & Arthur R. Kruckeberg[JM]	Uncertain distinctiveness from north coast plants, which may be an undescribed taxon
Streptanthus glandulosus var. *hoffmanii*	Roy E. Buck, Dean W. Taylor & Arthur R. Kruckeberg[JM]/Roger Raiche	Uncertain circumscription from ssp. *secundus.*
Streptanthus glandulosus var. *sonomensis*	Roy E. Buck, Dean W. Taylor & Arthur R. Kruckeberg[JM]/Roger Raiche	Uncertain circumscription from ssp. *secundus.*
Streptanthus morrisonii sspp. *elatus, hirtiflorus, kruckebergii,* and *morrisonii*	Roy E. Buck, Dean W. Taylor & Arthur R. Kruckeberg[JM]/Rebecca Dolan & Lawrence F. LaPré/Roger Raiche	Uncertain circumscription of varieties.

TABLE 1. CONTINUED

Scientific name	Authorities	Research problem
Tiarella trifoliata var. *trifoliata*	Patrick E. Elvander[JM]/Patricia K. Holmgren	Uncertain distribution and distinctiveness from var. *unifoliata.*
Trichocoronis wrightii var. *wrightii*	A. Michael Powell[JM]/Andrew C. Sanders	Perhaps best treated as a full species distinct from Texas plants.
Trifolium polyodon	Duane Isely[JM]/Vernal L. Yadon/John M. Gillett/Michael Vincent	Uncertain distinctiveness from *T. variegatum.*
Trifolium trichocalyx	Duane Isely[JM]/Vernal L. Yadon/John M. Gillett/Michael Vincent	Possible unstabilized hybrid.
Vaccinium coccineum	Gary D. Wallace[JM]/Jim Pushnik	Uncertain distinctiveness from *V. membranaceum.*

own or their students' research efforts, and to contribute information in their possession to resolve these issues. In addition to a vast and complex flora replete with rare plants, California has a remarkably large and active botanical community. These factors converge to make it most difficult for any single party to have a comprehensive understanding of what rare plant research is required and who is doing it. We propose that this function be assumed by the CNPS Rare Plant Scientific Advisory Committee (RPSAC), which already maintains active databases tracking progress on rare plant information needs in California. Such a system will serve several functions, including minimizing duplication of effort and focusing research on issues of scientific and conservation importance. In particular, students who are embarking on research programs at levels ranging from senior theses to doctoral dissertations may find topics of interest, or may be able to restructure current studies to contribute information of conservation importance.

This effort integrates well with a new CNPS grant program. Starting in 1995, the RPSAC will administer modest grants of up to $1000/year to encourage resolution of taxonomic and distributional uncertainty which limits protection of California's rare flora. Information on this grant program will soon be published in the CNPS *Bulletin,* and is also available from the CNPS State Office, Rare Plant Program, or Vice President for Plant Programs.[1] Comparable grants are also available from the Hardman Foundation and, to a limited extent, from the CNPS Grants Committee.

Note that we have included only scant outlines of each problem in the tables; readers will need to consult existing published references such as Munz and Keck (1973), Munz (1974), the *Inventory,* the *Manual,* and other treatments and references for a more detailed understanding. In most cases the CNPS Rare Plant Program and the NDDB have additional information on file or in digital form for distribution. We hope that persons planning research programs will contact the authorities listed in the tables to discern current research efforts and help guide their own. We also recommend consulting with *Flora of North America* (FNA) authors for more information, since many treatments of California plants are currently in preparation and hopefully some of the taxonomic and distributional enigmas listed here will be clarified by FNA treatments. (Contact the Missouri Botanical Garden in St. Louis for FNA author information; we have included authors known to us.)

The present compilation is far from complete, and we welcome additional information to reduce gaps in our knowledge of what

[1] CNPS State Office phone number is (916) 447-2677, Rare Plant Program is (916) 324-3816 or 327-0714, and Vice President for Plant Programs is (415) 705-2691.

needs to be done. Furthermore, we emphasize that our intention here is not to offend conscientious workers who may have settled these issues already, or feel that they have. We acknowledge our ignorance of much important work on California's rare plants, so please send us your important conclusions if it appears we are unfamiliar with them. For example, although published several years ago, we only recently became aware of a taxonomic treatment affirming that *Scutellaria holmgreniorum* is a synonym of *S. nana* (Olmstead 1990); we can now evaluate this work and consider deleting *S. holmgreniorum* from the *Inventory* and NDDB *Special Plants List* (NDDB 1994).

Publication of results in peer reviewed scientific journals promotes acceptance of taxonomic ideas, and generally, unpublished conclusions must be regarded as tentative. In several cases compiled here, research having important bearing on California plant conservation has been completed but not yet published, as with current studies of coastal *Arabis* (Vorobik 1994, personal communication). These cases are identified in the tables for the sake of completeness. The remaining plants in Tables 1 and 3 are included either because information is lacking (the vast majority) or we judge that no adequate taxonomic treatments exist.

Research Needs

Endangered species protection rests on widespread agreement about a species' taxonomic status, distribution and abundance, and type and magnitude of threats. Uncertainty in any of these areas encourages opponents of protection, who frequently will claim that a taxon is not worthy of recognition or should be recognized at some lower taxonomic level, is more common than biologists think, or is not severely threatened. Some examples are given below in the text. Unlike Messick (1987), who addressed a broad range of necessary studies in his useful compendium of research needs for California rare plants, here we stress only the distributional and taxonomic information necessary to better assign conservation status and prioritize protection activities, which may include more detailed future autecological, genetic, and recovery research.

Taxonomic Uncertainty

Uncertainty regarding the nomenclatural status of rare species (Table 1) lowers their protection priority, and typically must be resolved before protection or conservation measures can be established. In 1990, a petition was filed with the State of California to list *Chorizanthe robusta* var. *hartwegii* as an endangered taxon. The petition was challenged by listing opponents and their biological

consultant on the grounds that the var. *hartwegii* is indistinct from var. *robusta.* An inconclusive battle of taxonomic experts ensued, and the petition was subsequently rejected at the State level, primarily because of taxonomic uncertainty. Convinced that taxonomic controversy would complicate Federal listing of this plant and three of its close relatives, the US Fish and Wildlife Service convened a panel of experts from UC Berkeley to review the distribution and taxonomy of the *Chorizanthe pungens/C. robusta* complex. The panel returned the verdict that the complex does have recognizable and modally well-defined phases without strong boundaries (Ertter 1990). The Service proceeded with the listings, though it sidestepped the taxonomic issues in part by listing *C. robusta* as a whole rather than listing the two varieties separately, an option because the entire species is endangered. Nevertheless, taxonomic uncertainty caused delays that were costly to conservationists since time was wasted and protection lagged, and expensive to opponents who squandered money on biological consultants and lawyers hired to challenge the authenticity of taxa. And had the outcome been different and the taxa judged indistinct, once again conservationists would have needlessly sacrificed credibility by investing time and effort to protect taxa of dubious taxonomic validity.

The rough criteria that we established for inclusion on the list of taxonomically unresolved rare California plants are outlined below and in the next paragraph. Many of the plants included here were reduced to synonymy or embedded within other entries in the *Manual,* yet for various reasons may merit taxonomic recognition (Skinner and Ertter 1993, Skinner and Pavlik 1994). For example, the taxonomic status of *Dudleya alainae* remains controversial despite its designation as a synonym of *D. aloides* ssp. *saxosa* in the *Manual.* Other taxa included here were recognized or mentioned in the *Manual,* but authors expressed uncertainly about the proper level of taxonomic recognition or were unsure of taxonomic limits. For example, knowledgeable field botanists in Sonoma County feel that the subspecies of *Streptanthus morrisonii* are distinct and merit separate recognition, notwithstanding the parenthetical (embedded) treatment of those subspecies in the *Manual* and ongoing confusion regarding their circumscription.

Taxa at the specific, subspecific, or varietal rank that are known to introgress with close relatives, or that hybridize sporadically but which nevertheless are morphologically or genetically defined over their core distribution are not included here. Many rare plants in *Arctostaphylos, Chorizanthe, Eriogonum, Monardella,* and many genera of Asteraceae, to name only a very few, display this pattern. In fact, this phenomenon has informally been referred to as the "California pattern" since it is so widespread here. Among other causes, it arises from the relative modernity of much of our flora

and resultant incomplete development of reproductive isolating mechanisms (Stebbins and Major 1965). It follows that the existence of hybridization or zones of introgression between otherwise well-defined taxa does not invalidate them, nor in most cases would additional study clarify the situation. Taxa are included below if there is significant uncertainty about the degree of introgression, and consequently, about the distributions of taxa involved. In theory, conservationists might want to minimize awareness of the extent of hybridization between rare plants for at least two reasons: typically there is no legal protection for hybrids, and the existence of hybrids or broad zones of intergradation is often interpreted by non-biologists as evidence that taxa are not distinct. The reality of Nature is much less convenient.

The distribution of taxonomic problems affecting rare plants as currently catalogued in the *Inventory* is highly uneven across different groups (Table 2). Some large genera typically considered to be taxonomically or distributionally complex are riddled with taxonomic problems affecting rare representatives (e.g., *Lupinus, Mimulus, Streptanthus, Chorizanthe, Malacothamnus*), while, by our accounting, others (e.g., *Astragalus, Arctostaphylos, Galium, Dudleya, Calochortus,* and *Carex*) are virtually free of such problems. A simple explanation of this inconsistency is not forthcoming. The history of taxonomic study probably plays a major role in any explanation, however, since some groups have been treated more frequently, more recently, or more comprehensively, leading either to cleaner taxonomic schemes or to the perception that they are cleaner (Shevock 1993). In other cases, lack of taxonomic uncertainty in a genus indicates lack of intensive research; until studied some genera seemingly present few problems. Regardless, competent specialists who can provide clean identifications contribute to perception that groups are taxonomically tractable.

Evolutionary history also probably contributes significantly, since some groups apparently do consist of specific and infraspecific taxa that are better demarcated and hence more easily separable. It is also likely that in some difficult groups such as *Arctostaphylos* or *Dudleya,* messy distributional patterns and resulting taxonomies are acknowledged and accepted by the botanical public and not considered to be problematic. With respect to any patterns or lack thereof in Table 2, it is probably safest merely to reiterate that Table 1—the basis of Table 2—is an incomplete compendium of rare plant taxonomic problems in California that is based on our current knowledge. We are not suggesting that genera missing or poorly represented in Table 2 are necessarily taxonomically clean; we merely assert our current ignorance of taxonomic controversies that affect our ability to define and protect rare representatives in these groups.

Many of the problems compiled in Table 1 can be approached

TABLE 2. TAXONOMIC UNCERTAINTY AMONG CALIFORNIA GENERA WITH MANY RARE PLANTS. Taxa are arranged by descending representation in the *Inventory*. Column 3 (number of *Inventory* taxa with taxonomic problems) sums the problematic taxa from Table 1.

Genus	No. taxa in *Inventory*	No. *Inventory* taxa w/ tax. problems	% w/tax. problems
Eriogonum	71	5	7
Astragalus	66	0	0
Arctostaphylos	57	1	2
Lupinus	30	7	23
Galium	29	0	0
Mimulus	29	12	41
Phacelia	28	2	7
Dudleya	27	1	4
Calochortus	25	0	0
Carex	25	0	0
Clarkia	25	2	8
Arabis	24	3	13
Streptanthus	24	8	33
Chorizanthe	23	6	26
Erigeron	23	1	4
Monardella	23	4	17
Delphinium	19	2	11
Ceanothus	18	5	28
Penstemon	18	1	6
Allium	17	0	0
Castilleja	17	3	18
Cordylanthus	17	1	6
Ivesia	17	0	0
Lomatium	16	1	6
Malacothamnus	16	12	75
Sidalcea	16	0	0
Cryptantha	15	3	20
Navarretia	15	0	0
Draba	14	0	0
Hemizonia	14	1	7
Linanthus	14	0	0
Fritillaria	13	1	8
Horkelia	13	3	23
Lotus	13	0	0
Atriplex	12	1	8
Lilium	12	0	0
Plagiobothrys	12	5	42
Ribes	12	2	17
Camissonia	11	1	9
Cirsium	11	1	9
Senecio	11	2	18
Erysimum	10	0	0
Juncus	10	0	0
Lewisia	10	4	40
Calystegia	9	2	22
Cupressus	9	1	11
Erythronium	9	1	11

TABLE 2. CONTINUED

Genus	No. taxa in *Inventory*	No. *Inventory* taxa w/ tax. problems	% w/tax. problems
Heuchera	9	1	11
Opuntia	9	3	33
Potentilla	9	0	0
Trifolium	9	2	22
Eriophyllum	8	0	0
Hesperolinon	8	0	0
Lessingia	8	1	13
Sedum	8	2	25
Epilobium	7	0	0
Gilia	7	0	0
Hulsea	7	0	0
Lathyrus	7	1	14
Layia	7	0	0
Limnanthes	7	1	14
Arnica	6	1	17
Botrychium	6	0	0
Brodiaea	6	0	0
Campanula	6	0	0
Eryngium	6	1	17
Eschscholzia	6	2	33
Madia	6	0	0
Oxytheca	6	0	0
Pedicularis	6	1	17
Pinus	6	0	0
Poa	6	0	0
Potamogeton	6	0	0
Salvia	6	1	17
Silene	6	1	17
Viola	6	0	0
Acanthomintha	5	0	0
Eriastrum	5	0	0
Ericameria	5	0	0
Gentiana	5	1	20
Iris	5	0	0
Lepidium	5	0	0
Malacothrix	5	0	0
Minuartia	5	0	0
Muhlenbergia	5	0	0
Orcuttia	5	0	0
Perideridia	5	1	20
Pogogyne	5	1	20
Sanicula	5	0	0
Selaginella	5	0	0
Thermopsis	5	0	0
Triteleia	5	0	0

through standard systematic methodology involving review of existing herbarium specimens and literature, examination of type specimens, field surveys and specimen collecting to document distribution and ecology, and morphological comparisons, including relatively sophisticated statistical procedures such as multivariate analyses. Resolution of some taxonomic controversies will be facilitated by molecular studies of the focus taxon and its close relatives, or through a combination of morphological and molecular approaches. Recent comparison of allozymes and RAPD genomic markers allowed Swensen et al. (1995) to conclude that *Malacothamnus fasciculatus* var. *nesioticus,* which was reduced to synonymy in the *Manual,* merits taxonomic recognition. Common garden experiments, which minimize the effect of environment on phenotypic expression, can be most illuminating. Regardless of the approach, broad sampling covering the distribution of subject taxa and careful selection of close relatives to be included in any study is crucial. Barring explicit demonstrations of actual reproductive isolation, only with an understanding of the degree of variation typically present in taxa of a given rank for a given group can appropriate taxonomic decisions be made in that group.

Distributional Uncertainty

The recent discoveries in California of outstanding botanical novelties such as *Neviusia cliftonii* (Shevock et al. 1992) and *Ceanothus ophiochilus* (Boyd et al. 1991) highlight the often substantial gaps in our knowledge of California's plants and where they occur (see also Shevock and Taylor 1987). Many areas of the state are poorly collected, and our knowledge of those floras is correspondingly weak. Very recent surveys by Glenn Clifton and other consulting biologists in the Modoc Plateau have revealed nine taxa previously unknown in California, including *Atriplex garderi* var. *falcata, Psoralidium lanceolatum, Stanleya viridiflora,* and *Triteleia grandiflora* ssp. *howellii.* But poorly known areas need not be remote. During field work conducted over the past three years, one of the authors (A. Sanders) has added over 100 new plants to the flora of the San Bernardino Mts., a much botanized range that is easily visible from Los Angeles, the second largest metropolis in the United States.

Less spectacular than striking new discoveries such as *Neviusia* but no less important are gaps in our understanding of the distributions of other California plants known for some time to be rare or endangered. These taxa are often small (e.g., *Psilocarphus*), overlooked because of taxonomic bias (e.g., many pteridophytes), or difficult to identify because of the presence of sibling species (e.g., *Camissonia lewisii* complex) or extensive hybridization (e.g., *Arc-*

tostaphylos, Calystegia, Corethrogyne filaginifolia vars., *Delphinium,* or *Lupinus*). Others such as *Potamogeton* live in aquatic habitats that are rarely surveyed or collected by terrestrial botanists. Many of these plants are also overlooked since they flower infrequently and are usually encountered in the vegetative state.

Distributional uncertainty (Table 3) limits conservation action in several ways. Taxa thought to be absent from an area are not included on "potential lists" of plants to be looked for during the environmental disclosure phase prior to completion of development projects which are subject to environmental quality laws (e.g., the California Environmental Quality Act and the National Environmental Policy Act). Despite the requirement that such fieldwork be floristic in nature and not focus on high probability rarities (Department of Fish and Game 1984), the reality is often otherwise. If taxa are not looked for and hence not found, protection at these sites is clearly compromised. Equally important, without firm knowledge of distribution and abundance it is impossible to assign definitive conservation ranks and priorities to rare plants, hence the placement of many poorly known taxa on CNPS List 3 (list of plants about which we need more information) in the *Inventory.* Lastly, poorly known or recently discovered taxa are often assumed by opponents of endangered species protection to occur in other areas and therefore to be too common for concerted protection efforts. In certain cases they are correct. Although Federally listed as a threatened species in 1990, recent field surveys have revealed that *Eriastrum hooveri* is considerably more common in the San Joaquin Valley than previously thought, and it is already a candidate for delisting. During the recent listing process that provided California Endangered Species Act protection to *Ceanothus ophiochilus,* opponents repeatedly challenged biologists' knowledge of the plant's distribution, and correctly argued that other populations might exist in addition to the lone known locality at Vail Lake in Riverside County. That two additional small populations were discovered nearby is unsurprising given the very recent description of the species, but both this and *Eriastrum hooveri's* relative abundance vis-a-vis our lower estimates underscore the need for additional field and herbarium surveys for many of California's rare and endangered plants.

Our ignorance of the relative abundance and distribution of many species both common and rare tends to be hidden in the broad statements about species range that occur in statewide and regional floras. Many rare plants are so poorly known that their rarity remains obscure, and only floristic field work which considers the status and distribution of all species within the study area will reveal these rarities. We need more broadly based floristic field work and collecting!

TABLE 3. COMPILATION OF DISTRIBUTIONAL RESEARCH NEEDS FOR THE RARE FLORA OF CALIFORNIA. Criteria for inclusion are discussed in the text. Consult Hickman (1993), Skinner and Pavlik (1994), and the CNPS Rare Plant Program for more information about each entry. JM Author(s) of *The Jepson Manual* treatment. * Research completed, but not yet published. † Deceased.

Scientific name	Authorities	Research problem
Abronia maritima	Richard Spellenberg[JM]	Unknown abundance and vigor in northern portion of distribution and Channel Islands.
Agrostis humilis	M. J. Harvey[JM]/Kurt R. Neisess	Uncertain distribution and abundance; probably more widespread in CA.
Androsace elongata ssp. *acuta*	Anita F. Cholewa & Douglass M. Henderson[JM]	Uncertain distribution and abundance; many historical occurrences extirpated.
Arenaria macradenia var. *kuschei*	Ronald L. Hartman[JM]/Tim Ross	Unknown distribution and abundance; known from only a single collection from 1929.
Arnica fulgens	Theodore M. Barkley[JM]/Stephen R. Downey & Keith E. Denford/William Gruezo	Uncertain distribution and abundance.
Atriplex serenana var. *davidsonii*	Dean W. Taylor & Dieter H. Wilken[JM]/David Bramlet/Craig Reiser	Uncertain distribution and abundance.
Atriplex minuscula	Dean W. Taylor & Dieter H. Wilken[JM]/John Stebbins	Uncertain distribution and abundance.
Atriplex depressa	Dean W. Taylor & Dieter H. Wilken[JM]	Uncertain distribution and abundance.
Azolla mexicana	Alan R. Smith[JM]	Uncertain distribution and abundance; difficult to distinguish from *A. filiculoides,* which is common.
Boschniakia hookeri	Lawrence R. Heckard† [JM]	Uncertain distribution and abundance in northern CA and beyond.
Calandrinia breweri	Walter A. Kelley[JM]	Uncertain distribution and abundance; widespread, but most collections are old.
Calochortus weedii var. *vestus*	Peggy Fiedler & Bryan D. Ness[JM]/H. P. McDonald	Uncertain distribution and abundance in Santa Lucia Mtns.
Calyptridium parryi var. *hesseae*	Dieter H. Wilken & Walter A. Kelley[JM]	Uncertain distribution and abundance.
Calystegia sepium ssp. *binghamiae*	Richard K. Brummitt[JM]	Uncertain distribution and abundance; possibly extinct.
Cardamine pachystigma var. *dissectifolia*	Reed C. Rollins[JM]	Uncertain distribution and abundance.

TABLE 3. CONTINUED

Scientific name	Authorities	Research problem
Caulanthus simulans	Roy E. Buck[JM] */Andrew C. Sanders	Uncertain distribution due to similarity with *C. heterophyllus* var. *pseudosimulans* (unpublished).
Carex comosa	Joy Mastrogiuseppe[JM]/Glenn Clifton	Uncertain distribution and abundance, since apparently rarely collected.
Carex sheldonii	Joy Mastrogiuseppe[JM]	Uncertain distribution and abundance.
Cercocarpus betuloides var. *blancheae*	Richard A. Lis[JM]	Unknown distribution on other Channel Islands.
Chamaesyce platysperma	Daryl L. Koutnik[JM]/R. Mitchel Beauchamp	Uncertain distribution and abundance.
Chorizanthe parryi var. *parryi*	James C. Hickman† [JM]/James L. Reveal & Clare Hardham/Steve Boyd/David Bramlet	Uncertain distribution and abundance; confused with *C. procumbens,* and many historical occurrences extirpated.
Collinsia corymbosa	Elizabeth Chase Neese[JM]	Uncertain distribution and abundance.
Epilobium howellii	Peter C. Hoch[JM]	Uncertain distribution and abundance.
Equisetum palustre	Richard L. Hauke[JM]	Uncertain distribution and abundance.
Ivesia arizonica var. *arizonica*	Barbara J. Ertter[JM]	Uncertain distribution and abundance.
Juncus marginatus var. *marginatus*	Janice Coffey Swab[JM]/Barbara Ertter	Distribution poorly documented.
Lessingia hololeuca	Meredith A. Lane[JM]	Uncertain distribution and abundance; probably relatively widespread.
Lomatium congdonii	Lincoln Constance[JM]	Plants from Red Mt., Mendocino Co. vouchered at UC may be this taxon.
Limosella subulata	Margriet Wetherwax[JM]/Niall McCarten & Roxanne Bittman/Brad Olson	Uncertain relationship to plants from East Coast.
Madia yosemitana	David J. Keil[JM]/Bruce G. Baldwin	Uncertain distribution and abundance; easily overlooked.
Marsilea oligospora	Alan R. Smith & Thomas Lemiuex[JM]/David M. Johnson	Uncertain distribution and abundance.
Monardella candicans	James D. Jokerst[JM]	Present distribution poorly documented; many historical occurrences.
Navarretia leucocephala ssp. *bakeri*	Alva G. Day[JM]/James D. Jokerst	Uncertain distribution and abundance; may be more widespread.

TABLE 3. CONTINUED

Scientific name	Authorities	Research problem
Piperia michaelii	Dieter H. Wilken & William F. Jennings[JM]/ James D. Ackerman/R. Morgan	Uncertain distribution and abundance; probably relatively widespread.
Polystichum lonchitis	Alan R. Smith & Thomas Lemieux[JM]/David Wagner	Uncertain distribution and abundance.
Potamogeton epihydrus ssp. *nuttallii*	Robert F. Thorne[JM]	Uncertain distribution and abundance.
Potamogeton filiformis	Robert F. Thorne[JM]	Uncertain distribution and abundance; probably relatively widely distributed.
Potamogeton foliosus var. *fibrillosus*	Robert F. Thorne[JM]	Uncertain distribution and abundance; to be expected in Great Basin areas of CA.
Potamogeton praelongus	Robert F. Thorne[JM]	Uncertain distribution and abundance.
Potamogeton robbinsii	Robert F. Thorne[JM]	Uncertain distribution and abundance.
Potamogeton zosteriformis	Robert F. Thorne[JM]	Uncertain distribution and abundance, especially in the Central Valley.
Puccinellia pumila	Jerrold I. Davis[JM]/Arthur M. Phillips, III & Barbara G. Phillips	Possibly poorly known or undercollected in CA.
Selaginella densa var. *scopulorum*	Dieter H. Wilken[JM]/Ivan Valdespino/Alan R. Smith	Uncertain distribution and abundance.
Senecio hydrophiloides	Theodore M. Barkley[JM]	Uncertain distribution and abundance.

Extinct Plants, Some with High Rediscovery Potential

As natural habitat in California continues to shrink, it becomes imperative to rediscover populations of plants currently thought to be extinct (Table 4), and to safeguard populations that are found. Comprehensive, properly timed field survey of all remaining habitat for many of California's extinct plants is desirable now, before likely habitat is further degraded or eliminated by development, agriculture, exotic plants or animals, vehicles, or other destructive anthropogenic activities. Searching for extinct taxa can be fruitful: in the period between 1988 and 1994, thirteen taxa were relocated in California.

While some of the plants considered extinct in California are probably permanently gone (e.g., *Howellia aquatilis, Potentilla multijuga*; the latter discussed in Ertter 1993), others have high potential for rediscovery (e.g., *Monardella leucocephala, Tropidocarpum capparideum,* various *Mimulus* and *Plagiogothrys* spp.), but focused surveys of potential habitat have either not been conducted or have been sporadic or haphazard. Searches must be strategic and exhaustive, should build upon past unsuccessful efforts (consult CNPS for detailed information about protocols and search history), and should be conducted when plants are most visible and identifiable. Investigations should emphasize known localities with remaining habitat and nearby areas with appropriate vegetation and soils. Timing is critical since a high percentage of the plants in Table 4 are annuals (Pavlik and Skinner 1994) which may appear only in favorable wet years; searches in inauspicious years may be pointless. For example, a single plant of *Trifolium amoenum* was recently rediscovered in Sonoma County in May 1993 (Conners 1994), following the wettest winter in California in a decade.

Careful consideration of Table 4 reveals two noteworthy trends. Five of the 32 California plants that are presumed extinct occurred on the Channel Islands. This disproportionate representation is almost certainly linked to more than a century of devastating overgrazing practices and debilitating competition from exotic grassland plants. It remains distinctly possible that some of these taxa persist as seeds in the soil, and as overgrazing is controlled or eliminated on the Channel Islands some of these taxa may reappear. Twelve of the presumptive extinctions are known only from their type locality in California or its immediate vicinity, including nine known from only the type collection. Many of these taxa must be considered taxonomically suspect (e.g., *Castilleja uliginosa* and *Mimulus brandegei*). This is because adequate taxonomic comparisons are difficult or impossible with scant material for study, raising the likelihood that some of these taxa were described from aberrant or unusual

TABLE 4. EXTINCT PLANTS IN CALIFORNIA, SOME WITH HIGH REDISCOVERY POTENTIAL. Consult Hickman (1993), Skinner and Pavlik (1994), and the CNPS Rare Plant Program for more information about each entry, including details of recent rediscovery attempts. [L] Known only from the type locality and immediate vicinity. [T] Known only from the type collection. [o] Extant outside California.

Scientific name	Last seen	Notes
Arctostaphylos hookeri ssp. *franciscana*	1942	Known from only three occurrences in San Francisco; now occurs only in cultivation. Extirpated by residential development.
Astragalus mojavensis var. *hemigyrus*o	1941	Known in CA from only one collection from Darwin Mesa, Inyo Co. First collection in NV since 1939 made near type locality in 1985.
Astragalus pycnostachyus var. *lanosissimus*	1967	Habitat lost to urbanization. Recent attempts (including 1987) to rediscover this plant have been unsuccessful.
*Calochortus monanthus*T	1876	Known only from the type locality along the Shasta River, Siskiyou Co. Now mostly converted to agriculture; site degraded by overgrazing and non-native plants. Field surveys in 1990 and earlier unsuccessful.
*Carex livida*o	1866	Known in CA from only one collection near Mendocino City, Mendocino Co. Field surveys unsuccessful. Local experts doubt potential for rediscovery.
Catilleja uliginosa	1987	Known from two occurrences in Pitkin Marsh and Trembley's Marsh, Sonoma Co. Last known remaining plant died in 1987, despite management efforts. No access allowed by landowner after 1987.
Chorizanthe parryi var. *fernandina*	1940	Most historical habitat is now heavily urbanized. Numerous recent field surveys have been unsuccessful; most likely to be rediscovered in northwestern Los Angeles Co., especially in the Elizabeth Lake area.
Dissanthelium californicum	1912	Known in CA from only two occurrences on San Clemente and Santa Catalina Islands. Possibly extirpated by feral goats.
Erigeron mariposanus	1900	Collected several times from 1892–1900; localities vague. Suspected to occur in specialized habitats.
Eriogonum truncatum	1940	Much habitat eliminated by grazing and urbanization. Recent field surveys (including 1985–1987) unsuccessful.
Eschscholzia rhombipetala	1950	Field surveys in 1986, 1980, and earlier unsuccessful. Report from La Panza, San Luis Obispo Co. probably misidentified *E. lemmonii* ssp. *lemmonii*.
Helianthus nuttallii ssp. *parishii*	1937	Extirpated by destruction of marsh habitat by urbanization. Most likely to be rediscovered near Seven Oaks, San Bernardino Co.

TABLE 4. CONTINUED

Scientific name	Last seen	Notes
Howellia aquatilis○	1928	Known in CA from only one collection near Howard Lake, Mendocino Co. Possibly extirpated by cattle grazing and trampling. Numerous rediscovery attempts (1975, 1979, 1980, and more recent) unsuccessful.
Lycium verrucosum[T]	1901	Known only from the type collection on San Nicolas Island; locality vague. Field surveys (including 1978 and 1979) unsuccessful.
Malacothamnus mendocinensis	1939	Known from only two collections near Ukiah, Mendocino Co. Recent intensive field surveys unsuccessful.
Malacothamnus parishii[T]	1895	Only known from the type collection in San Bernardino Valley, San Bernardino Co. Extirpated by urbanization. Field surveys unsuccessful.
Mimulus brandegei[L]	1932	Known from only two collections on Santa Cruz Island. Possibly extirpated by grazing. Field surveys prior to 1979, in 1985, and 1992 unsuccessful.
Mimulus traskiae[T]	1904	Known only from the type collection near Avalon; locality vague. Possibly extirpated by grazing or development.
Mimulus whipplei[T]	1854	Known only from the type collection near Murphys, Calaveras Co. Many recent field surveys unsuccessful.
Monardella leucocephala	1941	Known from only three occurrences. Probably extirpated by agricultural conversion. Field surveys in 1986 unsuccessful, but high potential for rediscovery.
Monardella pringlei[L]	1921	Known from only two occurrences in the vicinity of Colton. Habitat lost to urbanization. Many recent field surveys unsuccessful.
Montia howellii○	1933	Known in CA from seven collections. Field surveys in 1989 and 1992 in CA unsuccessful; recent surveys located new populations in OR and WA. Sometimes mistaken for *M. fontana* or *M. dichotoma.*
Ophioglossum pusillum○	1894	Known in CA from only two occurrences.
Orthocarpus pachystachyus	1913	Known from only two collections, localities vague. Probably extirpated by agriculture and grazing.
Phacelia cinerea[T]	1901	Known only from the type collection on San Nicolas Island. Field surveys in 1977–1979 and others since 1983 unsuccessful.
Plagiobothrys glaber	1954	All collections since 1930's located in the Hollister area; plant should be looked for there. Possibly a variety or ecotype of *P. stipitatus.*

TABLE 4. CONTINUED

Scientific name	Last seen	Notes
Plagiobothrys hystriculus[T]	1892	Known only from the type collection in the Montezuma Hills; all other reports misidentifications. Easily confused with *P. acanthocarpus, P. trachycarpus,* and others.
Plagiobothrys lithocaryus[T]	1899	Known only from the type collection from Lakeport, Lake Co. in 1884 and an uncertain collection from Potter Valley, Mendocino Co. in 1899; should be looked for in these areas.
Plagiobothrys mollis var. *vestitus*[T]	1888	Known only from the type collection near Petaluma. Thought to be extirpated by agriculture in 1932.
Poliomintha incana[O]	1938	Known in CA from only one occurrence at Cushenbury Springs. Possibly extirpated by mining activities.
Potentilla multijuga[L]	1890	Known only from one occurrence near Ballona, Los Angeles Co. Extirpated by urbanization. Recent field surveys unsuccessful.
Tropidocarpum capparideum	1957	Field surveys (1974, 1978, 1979, 1981, 1986, 1987) unsuccessful.

representatives of more widespread close relatives. Barring discovery of new populations, confirmation of taxonomic independence for these taxa is unlikely.

Conclusion

Only time will tell whether it is possible for anyone to monitor the progress of rare plant research in California as we are attempting to do here. It is an enormous state with many contributing lay and professional researchers and conservationists, and with more than its share of complex botanical problems. Whether we are successful in addressing current problems and maintaining an active understanding of research needs for plant conservation in California depends solely on the participation of all who study our declining flora. We hope readers will send any information they currently possess which has bearing on the many and sometimes controversial problems outlined here to the CNPS Rare Plant Program; all such information is used jointly by the NDDB. We hope botanists will publish results of completed or long dormant studies. We also hope that researchers will seize upon the problems presented here for both their inherent scientific interest and immediate conservation applications.

So, focus your research on problems of conservation importance. Submit grant requests to CNPS and other organizations. Do the research, now. The fourth edition of the *Inventory* (Smith and Berg 1988) included 675 taxa on List 1B, the plants which are rare and endangered in California and everywhere else. The fifth edition includes 857 List 1B plants, a 27% increase in only six years. We are truly running out of time to establish and implement plant conservation priorities in California.

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